State Minimum Standards Training
2009 Composting Field Exercises Worksheet
Station C: How "Hot" Is This Stuff?

Background

Discovering the appropriate temperature of a given accumulation of compostable material requires the investigator to locate the points in the material accumulation relevant to the particular regulatory concern. Most are familiar with the regulatory requirements for temperature monitoring during the pathogen reduction process [14 CCR Sections 17868.3(d)] , but there are several other regulatory motivations for inquiry: excluded activities [14 CCR Sections 17867(a)(8)], impact minimization (process monitoring) [14 CCR Sections 17867(a)(2)], and fire prevention [14 CCR Sections 17867(a)(8)]. Each regulatory concern necessitates a different approach to temperature taking.

Pathogen Reduction

Per 14 CCR Sections 17868.3 directs operators and EAs to "ensure" the compost is below specified "pathogen" concentrations before it leaves the site. Additionally, Section 17868.3 describes the specific minimum requirements for pathogen reduction including maintenance of the compost at "55 degrees Celsius (131 degrees Fahrenheit) or higher" for a minimum of 15 days. The practice of "taking a representative sampling" can be applied to the gathering of a set of temperature readings.

Pathogen reduction is achieved by creating environments that are unsuitable for compost-borne pathogens. The self-heating aspect of compostable materials is employed along with the effects of superficial drying and exposure to oxygen. In windrow composting, agitation is added to ensure that a high percentage of the material has been exposed to appropriate temperatures. In theory all of the accumulated materials are "pasteurized" as opposed to "sterilized," and the compost is no longer "biological hot." Systematic assessment of the compostable materials' temperature history provides adequate verification of this "pasteurization" (a function of temperature over time).

Additionally, the EA has a high degree of flexibility in approving "alternative methods of compliance to meet the requirements" for pathogen reduction. There is really only one question to ask: will the operator be able to "ensure" that pathogen reduction threshold values are not exceeded in compost leaving the site?

Other Temperature Considerations

The regulatory definition for "active composting" [14 CCR 17852(a)(1)] references "temperatures of at least 50 degrees Celsius (122 degrees Fahrenheit)" and specified respiration values as a lower regulatory threshold. If an operator is able to maintain all aspects of the operation's material handling below 122°F, the operator's activities are "excluded" and the requirements of 14 CCR Chapter 3.1 do not apply.

Active composting is a predominantly aerobic and exothermic process. The rate and resiliency of heating (or re-heating) of an accumulation of compostable material suggests a great deal about the constituents of that accumulation. Operators and regulators may use relative temperature data to monitor the composting process. Impact minimization is directly linked to the aerobic characteristics of an accumulation of compostable materials. Comprehensive information on the biological aspects of compost and BMPs is available at http://www.ciwmb.ca.gov/LEACentral/Compostables/default.htm and the C-CORP report http://ciwmb.ca.gov/Publications/default.asp?pubid=1241 is a valuable resource.

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Fire Prevention

No regulatory upper threshold is identified, but in most instances, biological activity is replaced by chemical decomposition by 80 degrees Celsius (175 degrees Fahrenheit). Fires result from the rapid oxidation of compostable materials, and operators must "provide fire prevention, protection, and control measures" including temperature monitoring [14 CCR 17867(a)(8)] .

The "fire tetrahedron" states that all four elements must be present for a fire to occur: (1) fuel – if a material is compostable, as it dries, it may become combustible; (2) oxygen – respiration of a compostable material requires oxygen, as does a fire, < 5% O_2 will sustain a fire; (3) heat – the rise in temperature of a compostable material indicates a build-up of heat; (4) chemical reaction – an accumulation of compostable material.

To protect the environment, public health and safety, we might ask "What temperature reading is reason for fire concern in a pile of ground green material, and in a pile of un-ground green material?" It is not necessarily the cellulose or woody component that starts the combustion, since biological decomposition (along with chemical oxidation) produces hydrocarbons and other intermediates that are easily ignited. Also it is almost impossible to "know" the temperature of the pile unless it is a small and/or highly homogeneous pile.

Here are a few rules of thumb for temperature readings* where immediate action is recommended:

Un-ground or partially processed material, variable moisture, containing green grass or wet "fines," in large piles (over 500 cubic yards, over 10 feet high) …… **80ºC/176ºF**

Un-ground material, variable moisture, containing green grass or wet "fines," in small piles (less than 200 cubic yards, over 6 feet high) …… **90ºC/194ºF**

Uniformly ground material, uniform moisture and temperature, containing "fines," in large piles (over 500 cubic yards, over 10 feet high) …… **90ºC/194ºF**

Uniformly ground material, uniform moisture, containing "fines," small pile (less than 200 cubic yards, over 6 feet high) ……... **95ºC/203ºF**

*Assumes a high degree of measuring confidence for pile maximum temperature

1) More homogeneous, and freshly ground, more fire stable.

2) Pile size dictates heat retention.

3) Wet/dry interface starts many compostable materials fires.

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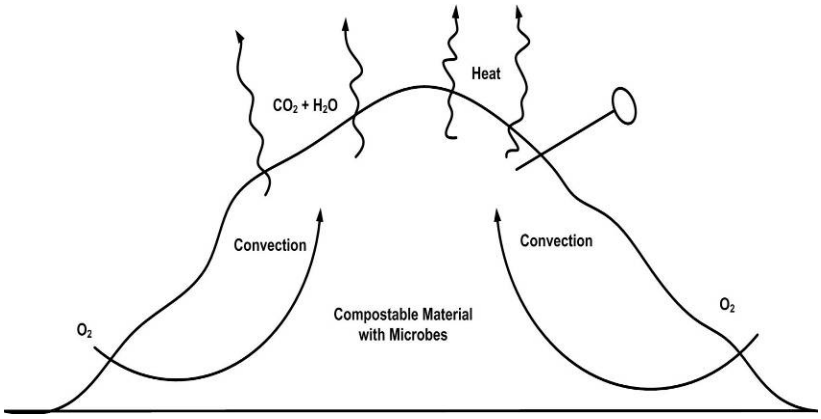
Exercise Instructions

This exercise is intended demonstrate the variability of temperature readings between different and within windrows/piles. Additionally, this exercise provides participants with experience in obtaining representative temperature readings associated with pathogen reduction and other regulatory requirements.



Exercise 1a - Select a representative cross-section of the designated windrow and take multiple temperature readings to create temperature profile of the cross-section. Record the readings on the diagram above and identify the location of cross-section in the length of the windrow.

Exercise 1b – Take temperature readings around/across/over the safely-accessible portions of the designated pile. Find the coolest and the hottest temperatures of pile. Sketch a picture of the windrow/pile and record the temperatures and their location.

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Exercise Questions

1. Where are the best locations in a windrow to measure a representative temperature for verification of pathogen reduction?

2. Where are the best locations to measure for verification of excluded activities?

3. Does the 15-day pathogen reduction period have to be 15 consecutive days?

4. What should the EA require of the operator before approving "alternative methods of compliance to meet the requirements" for pathogen reduction?

5. What are the conditions in the materials that favor elevated temperatures?

6. What effect would high winds have on the temperature readings and the associated risk of fire?

Supplemental Exercise: Imagine if you will, a large pile of green material (5,000 cubic yards, about 15 to 20 feet high, an uneven flat top) with relatively dry, unprocessed brushy materials on one side and moist unevenly ground materials on the other; the operator and the EA take temperature readings at 6 to 9 feet around the pile; ambient temperatures are observed from the brushy material and ambient plus 5 to 10°F consistently observed from the ground material; "steam" is observed coming off the top of the pile most of the day.

Is this material being maintained below 122°F and therefore an excluded activity?

Why is this material not composting?

What are the conditions that present the highest risk of fire?

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Ignition temperature . . .

the temperature at which more heat is generated by combustion than is lost to the surroundings, so that the combustion process becomes self-sustaining (Energy Technology Handbook, Considine).

The ignition temperature for most organic materials is 205 to 400°F (96 to 205°C).

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Feedstocks and Conditions Most Susceptible to Pile Fires

- **Raw, green feedstocks that may have already begun decomposing, such as a large brush pile.**
- **Bark chips if given enough moisture to start biological activity.**
- **Large piles of coarse compost, feedstock and screened over-sized material (particle size ~4"), such as bulking material, wood chips and mulch products.**

Prevention of Fires

- Allow pile heat dissipation by keeping pile height below 2 1/2-meters (8-9 feet)
- Keep pile moisture above 40%, and
- Keep moisture uniformly distributed

Monitor pile temperature!

These slides may only be used in CIWMB-sponsored trainings

Fires: Site Design Implications

- Provide enough space to avoid exceeding the fire-safe height of piles.
- Provide access to piles for fire fighting equipment (full perimeter access).
- Provide access to adequate supply of water.
- Provide space to spread piles out.